

Development and Integration of Sensor Technology for Determination of Respirator Service Life

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Project Goal

Produce an intelligent respirator with an end-of-service life indicator (ESLI) to determine when the performance of air-purifying respirators will become affected by contaminant breakthrough.

Partnerships

- U.S. Air Force
- Carnegie Mellon U
- UC San Diego

Stakeholders

- Respirator manufacturers
- Emergency responders
- Industrial workers

Background

- OSHA requires a change out schedule or ESLI for air-purifying respirator (APR) cartridges and powered air purifying respirator (PAPR) cartridges.
- No ESLI is available for organic cartridges.
- According to the 2001 NIOSH/BLS survey ~ 20% of establishments that use APRs allow their employees to determine respirator cartridge change out schedules.

Methods

A two-phase approach has been taken involving collaborations with: Carnegie Mellon University (CMU) and University of California San Diego (UCSD)

Approach (Sensing Motifs)

MicroElectroMechanical Systems (MEMS) - CMU

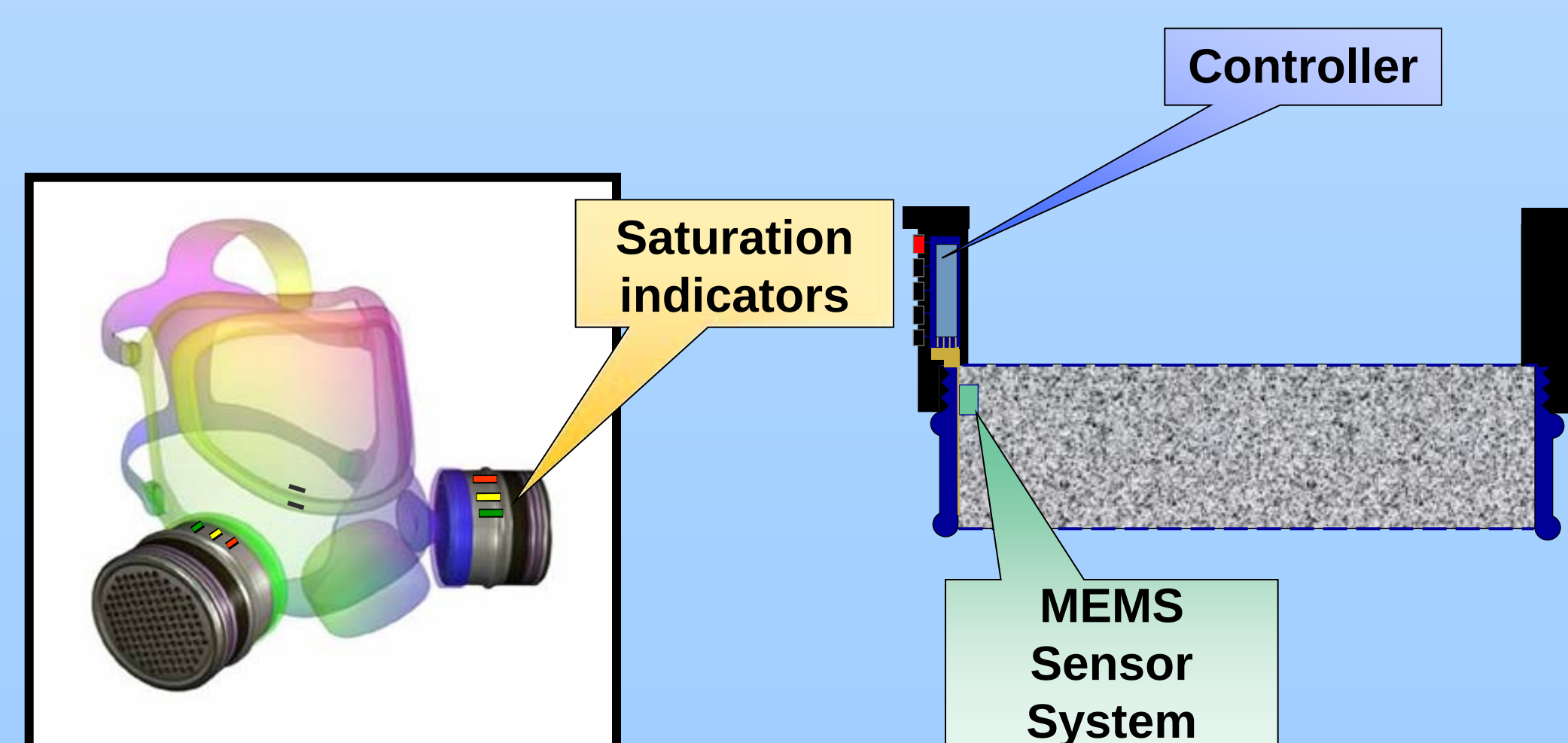


Figure 1. Concept depicting an air-purifying respirator with an integrated ESLI system

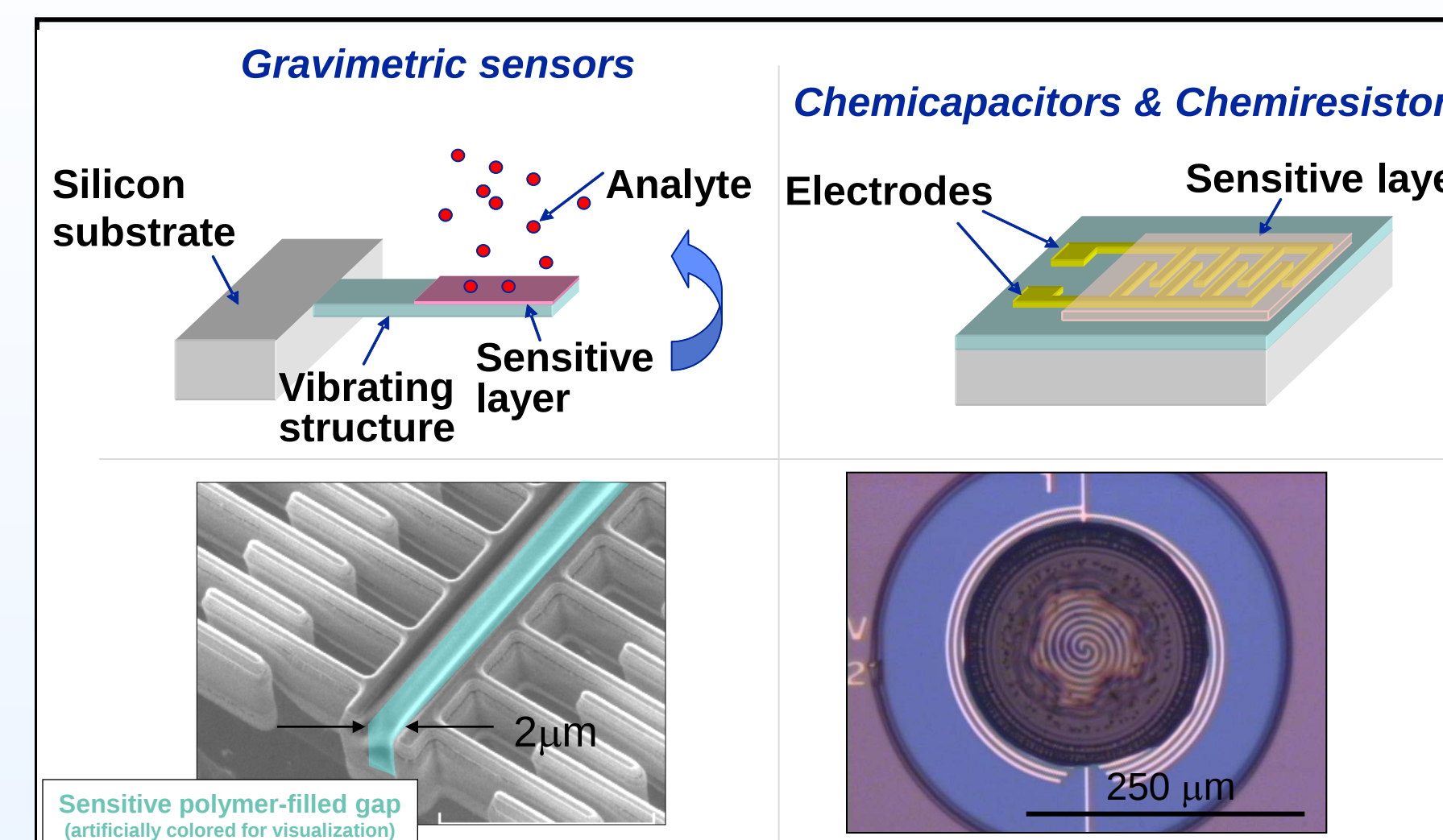


Figure 2. Multiple sensor types

Monolayer Protected Nanoparticles (MPN) - CMU

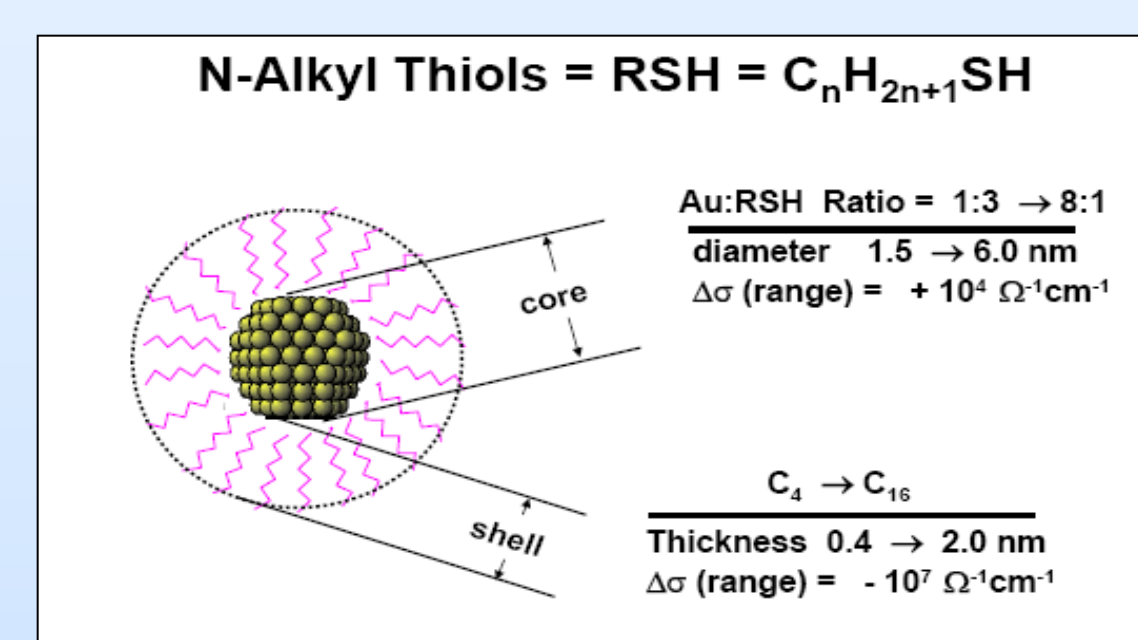


Figure 3. Family of organo-thiol gold nanoparticles

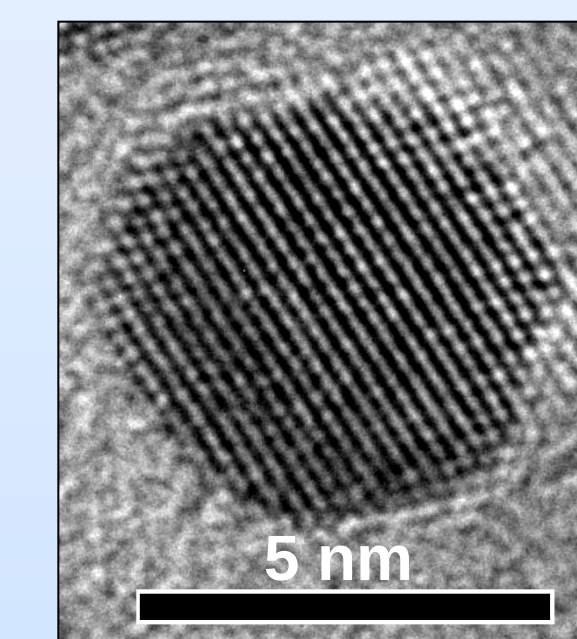


Figure 4. Example – TEM of alkane-monothiol core

Photonic Crystals – UCSD

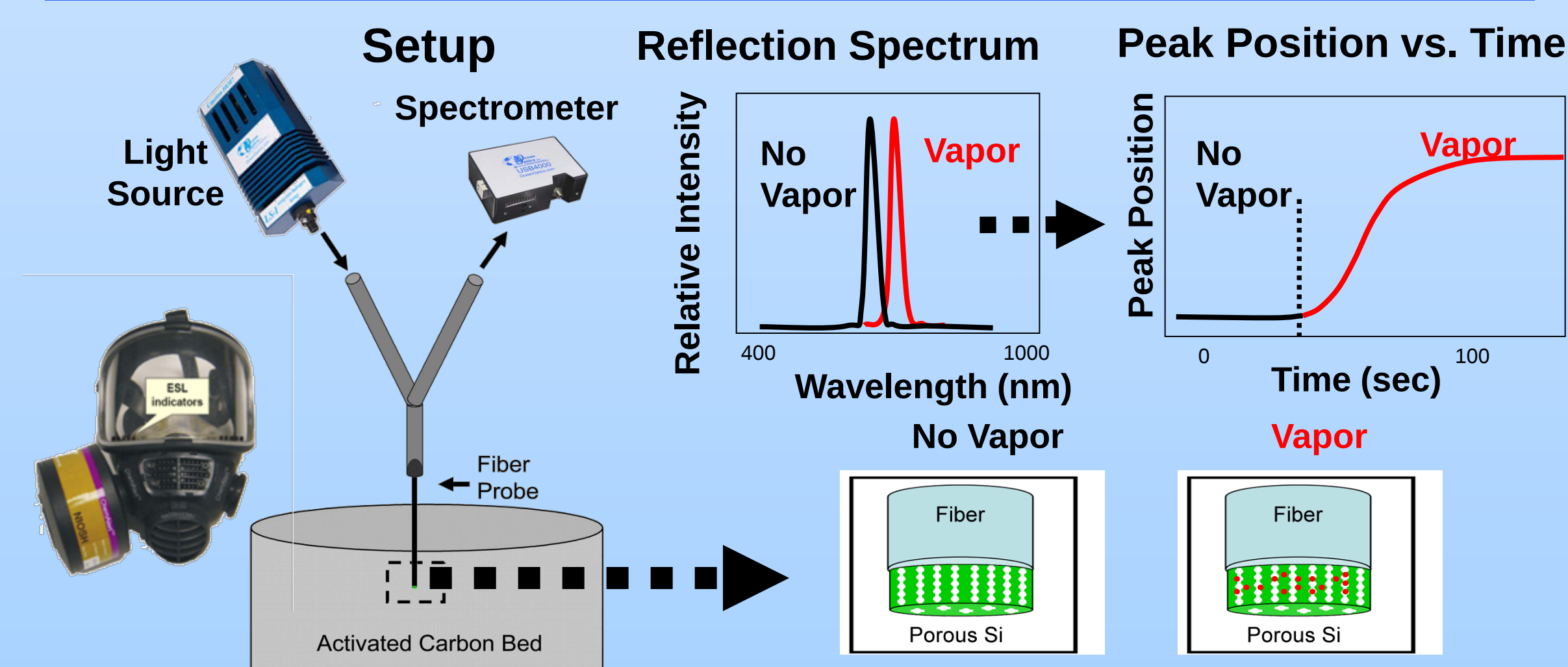


Figure 5. Left to right: Depiction of application as a gas mask end-of-service life sensor; Above/right: Experimental setup for in-situ monitoring of volatile organic compound (VOC) breakthrough in an activated charcoal filtration bed. Reflected light from an optical fiber-attached, embedded porous Si photonic crystal is monitored with a spectrometer

Disclaimer: The findings and conclusions in this poster have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy

Preliminary Results (CMU)

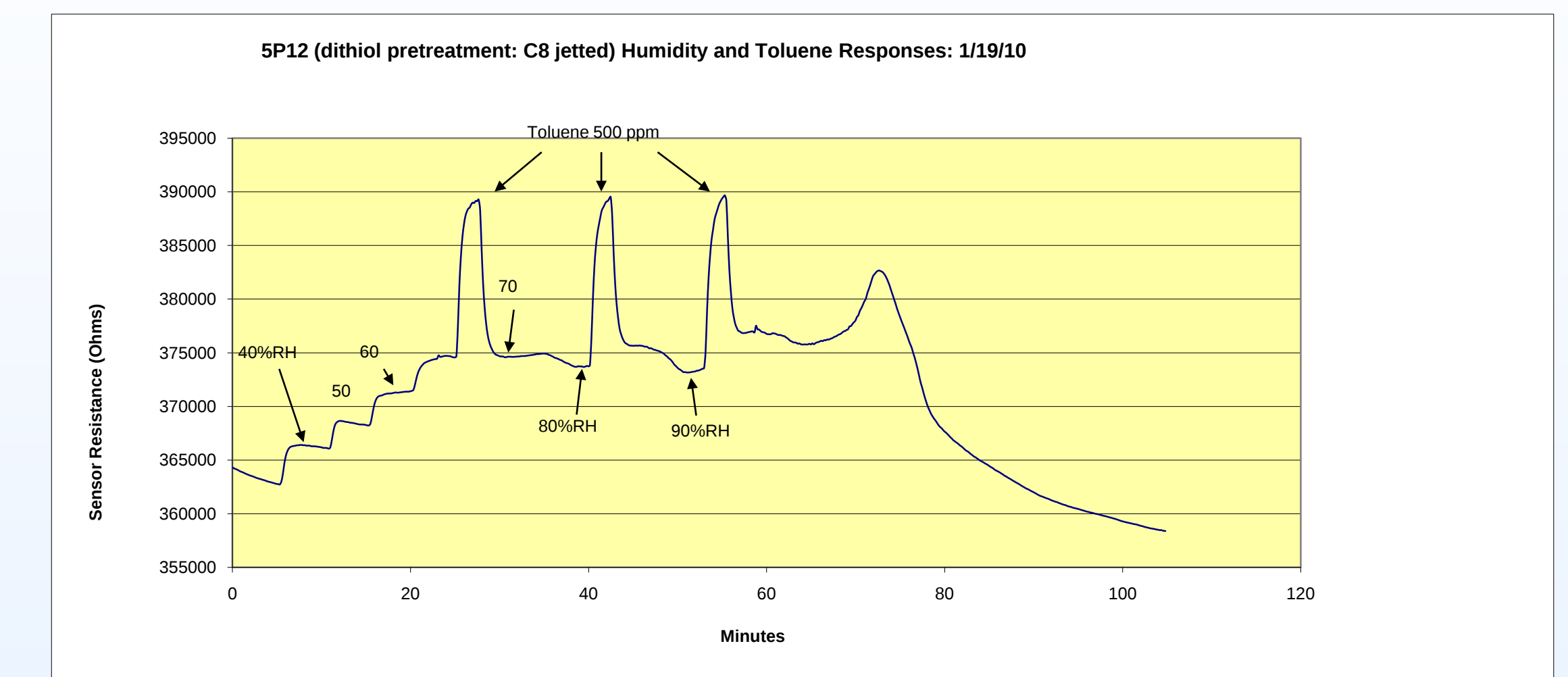


Figure 6. Sensitivity response of a monolayer protected gold nanoparticle film to toluene while varying the relative humidity.

Current Research

- Monolayer protected nanoparticle chemistry is being optimized.
- Photonic crystals are also being evaluated as an alternative approach.
- Partnerships with respirator manufacturers have been developed for the purpose of testing ESLI sensor prototypes (CMU) integrated into APR & PAPR cartridges.
- Testing with 60 APR cartridges from 6 manufacturers and another 10 PAPR cartridges from 1 manufacturer were completed, but analysis is still being done.

Outputs (partial list)

- Qian et al [2009] Controlling Nanoparticles with Atomic Precision: The Case of $\text{Au}_{144}(\text{SCH}_2\text{CH}_2\text{Ph})_{60}$. *Nano Lett.* 2009, 9, 4083-4087
- Bedair et al [2009] Picogram material dosing of microstructures. *Journal of Applied Physics* 106: 04913-7
- Fedder et al [2008] Jetted Nanoparticle Chemical Sensor Circuits for Respirator End-of-Service-Life Detection. *Proceedings of the 12th International Meeting on Chemical Sensors 2008 (IMCS 08)*, Columbus, Ohio, July 13-16, 2008, 2 pp.
- King et al [2007] Optical fiber-mounted porous silicon photonic crystals for sensing organic vapor breakthrough in activated carbon. *Advanced Materials* 19: 4530–4534.